AD-A053 616 SHELL DEVELOPMENT CO HOUSTON TEX F/G 13/2
DEVELOPMENT OF A NEW WRINGER FOR THE ZERO-RELATIVE-VELOCITY BEL--ETC(U)
NOV 77 J M WARD DOT-CG-42229-A

UNCLASSIFIED USCG-D-3-78 NL

| OF |

AD
A053616

END
DATE
FILMED
6 -78
DDC

12

Report No. CG-D-3-78

Task No. 4111.8

DEVELOPMENT OF A NEW WRINGER FOR THE ZERO-RELATIVE-VELOCITY BELT SKIMMER

J. M. WARD

NOVEMBER 1977

FINAL REPORT

Document is available to the U. S. public through the
National Technical Information Service,
Springfield, Virginia 22161

Prepared for

U. S. DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

Office of Research and Development
Washington, D.C. 20590

14 February 1978

NOTICE

W. L. King

W. L. KING
Captain, U. S. Coast Guard
Chief, Environmental and
Transportation Technology Division
Office of Research and Development
U. S. Coast Guard
Washington, D. C. 20590

Technical Report Documentation Page

1. Report No. (18) (19) US CG-D-3-78	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle (6) DEVELOPMENT OF A NEW WRINGER FOR THE ZERO-RELATIVE-VELOCITY BELT SKIMMER.		5. Report Date (11) November 1977
		6. Performing Organization Code Shell Development Company
7. Author's) (10) J. M. Ward		8. Performing Organization Report No.
9. Performing Organization Name and Address Shell Development Company Houston, TX 77001 (12) 36p.		10. Work Unit No. (TRAIS) 4111.8
		11. Contract or Grant No. (15) DOT-CG-42229-A
12. Sponsoring Agency Name and Address Office of Research and Development U. S. Coast Guard Washington, DC 20590 (11) Nov 77		13. Type of Report and Period Covered (9) Final Report. Jun-Oct 77. 6/77 - 10/77
		14. Sponsoring Agency Code G-DOE-1/TP54

15. Supplementary Notes
This Report supplements Report No. CG-D-23-77 entitled "A ZERO-RELATIVE-VELOCITY BELT SKIMMER; STAGE II - CONFIRMING TESTS AND PROTOTYPE DESIGN" AD41 416

16. Abstract

A simpler, lighter, and less expensive wringer mechanism has been developed for the ZRV Skimmer, a sorbent belt oil spill recovery vessel for use in fast currents. The new design, consisting of a large perforated drum and smaller peripheral rollers, is recommended to replace the original opposed conveyor design in the prototype skimmer. Performance tests comparing full-scale (but unit width) mock-ups of the new and original wringers showed that the new design works as well or better and requires less power than the original.

A brief summary of other changes made in the ZRV design since the publication of Report No. CG-D-23-77 (May 1977) is included as an appendix to this report.

17. Key Words Oil Skimmers Oil Spill Control Pollution Fast Current Oil Spill Control Wringers	18. Distribution Statement This document is available to the U. S. public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	38	

408 331

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

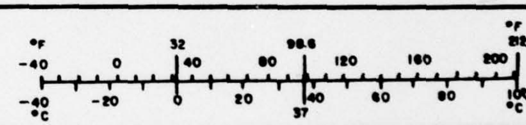


TABLE OF CONTENTS

I. INTRODUCTION

Since 1974 Shell Development Company has been working under contract to the U.S. Coast Guard to develop a device for effectively recovering spilled oil in 4 to 10-knot currents. The result of the project is a vessel design known as the ZRV Skimmer. This device is a sorbent belt skimmer which operates on the principle of maintaining approximately Zero Relative Velocity between an endless moving belt and the floating oil layer.

A Stage I program addressing the technical feasibility of the ZRV belt skimming concept determined what the prototype might look like and how it might perform.[1] In Stage II a full-scale mock-up of the oil recovery system was successfully built and tested to prove the skimming concept.[2] Results from the mock-up tests as well as from scale model vessel tests were then used to design a prototype ZRV skimmer. Test data from the mock-up indicated that the prototype would be able to recover up to 600 gallons per minute of oil in 6-8 knot currents.

Throughout the Stage II development the wringer mechanism was found to be the most critical component of the skimmer in terms of weight, cost, power consumption, and reliability. The mock-up wringer

---

1. Ayers, R. R., et al, "A Zero-Relative-Velocity Belt Skimmer", prepared by Shell Development Company for the U.S. Coast Guard, Contract DOT-CG-42229-A. Final Report, April 1975.

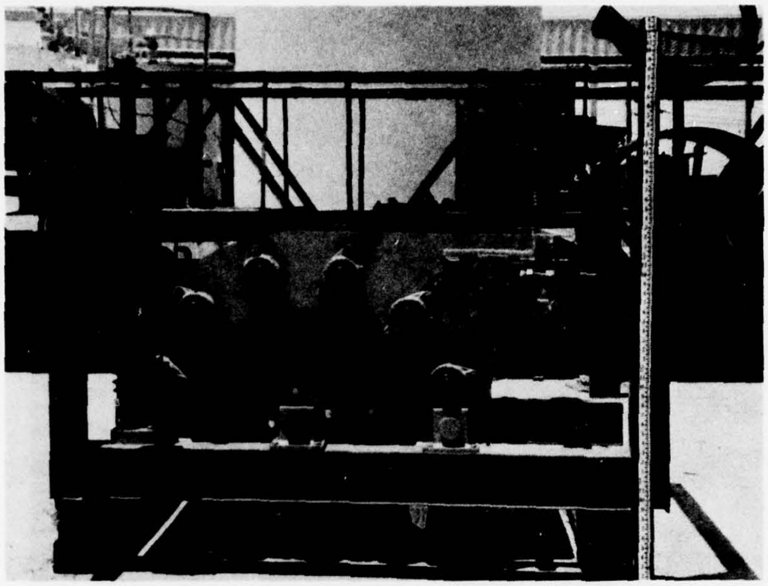
2. Ayers, R. R., and J. M. Ward, "A Zero-Relative-Velocity Belt Skimmer, Stage II - Confirming Tests and Prototype Design", Prepared by Shell Development Company for the U.S. Coast Guard, Contract DOT-CG-42229-A. Final Report, May 1977.

and its drive train made up about 30 percent of the cost and over 25 percent of the weight of the mock-up. An opposed tank-tread-like conveyor design was chosen for the mock-up because it had the highest probability of success for proving the ZRV belt concept. Indeed, the wringer worked well despite several correctible faults in design and manufacturing. However, weight, power consumption, operating life, and long term reliability were not particularly important to the successful operation of the mock-up.

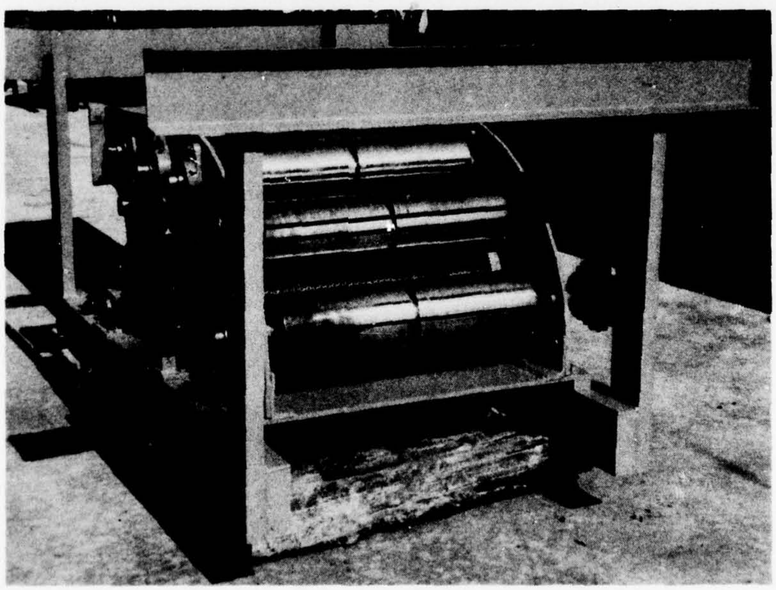
Weight, power, operating life, and reliability were very important in the design of a prototype. Taking these factors into account the original preliminary prototype design became very complex, required expensive construction techniques, and still exceeded weight limits for air-transportability. Thus, a recommendation was made to conduct a design and test program to develop a simpler, lighter, and less expensive wringer mechanism which would work as efficiently as the original design.

That wringer development program is the subject of this report. Chapter II describes the mechanical aspects of the new wringer design, how it works, and how it compares to the original. Chapter III discusses the test program conducted to compare the functional aspects of the two wringer designs. Performance data of a mock-up of the new wringer, shown in Figure 1, are compared against similar data obtained with the original mock-up wringer, shown in Figure 2.

Concurrent with the wringer development program the preliminary ZRV Skimmer design (reported in Reference 2) was revised to a detailed design. Most of the required work centered around the new wringer design described in Chapter II. Other significant changes are discussed in Appendix A.



Ready for Installation



With Belt Removed

Figure 1. New Mock-Up Wringer

0821

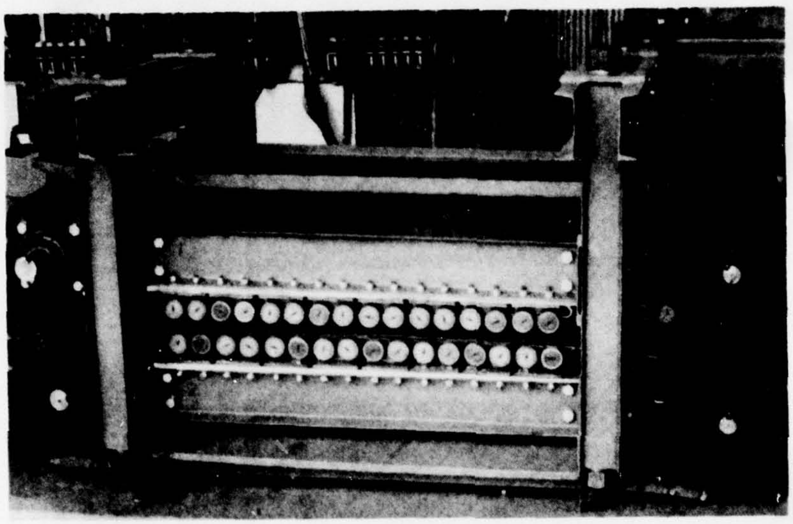


Figure 2. Original Mock-Up Wringer

0821

II. WRINGER DESIGN

Evaluation of Candidate Mechanisms

The design criteria listed in Table 1 were developed to evaluate candidate wringer mechanisms. These criteria were divided into two parts: process goals describing desired operating characteristics, and mechanical goals describing desired physical and mechanical characteristics. Each mechanism studied was rated according to these goals then the ratings were compared to eliminate the weakest of the candidates. The remaining mechanisms were studied more thoroughly and again compared to make a final choice for testing.

Various combinations of wipers, rollers (both solid and porous), and belt conveyors were evaluated. Wipers, while extremely simple and effective in removing oil from the surface of the sorbent belt, must be used with some type of driving type mechanism. Paired solid rollers also are simple but generate high compression rates as well as oil spray and have low driving traction. Perforated rollers offer an easy path of escape for oil, which controls spray somewhat, but are more mechanically complicated than solid rollers. Conveyor-type wringers (the original wringer was this type) can satisfy the process goals well but do poorly in meeting the mechanical goals.

Design Description

Figure 3 illustrates the main components of the new wringer design. It incorporates wipers on the take-up guide roller, as did the original wringer, but also adds a squeeze roller directly behind the guide roller. The gap between these rollers is set at a relatively

Table 1

Wringer Design Criteria

A. Process Goals:

1. High wringing efficiency to maximize oil recovery.

2. Low belt tension to avoid tearing belt splices.

3. Low shear on belt to avoid surface wear and stitch fatigue failure.

4. Low compression rates to minimize pore pressures and consequent belt degradation.

5. Low spray generation to minimize rewetting belt and emulsifying oil/water mixture.

6. High driving traction to prevent belt wear caused by slipping or sliding.

B. Mechanical Goals:

1. Simple design for high reliability.

2. Low power requirement.

3. Low weight.

4. Conventional construction for low cost.

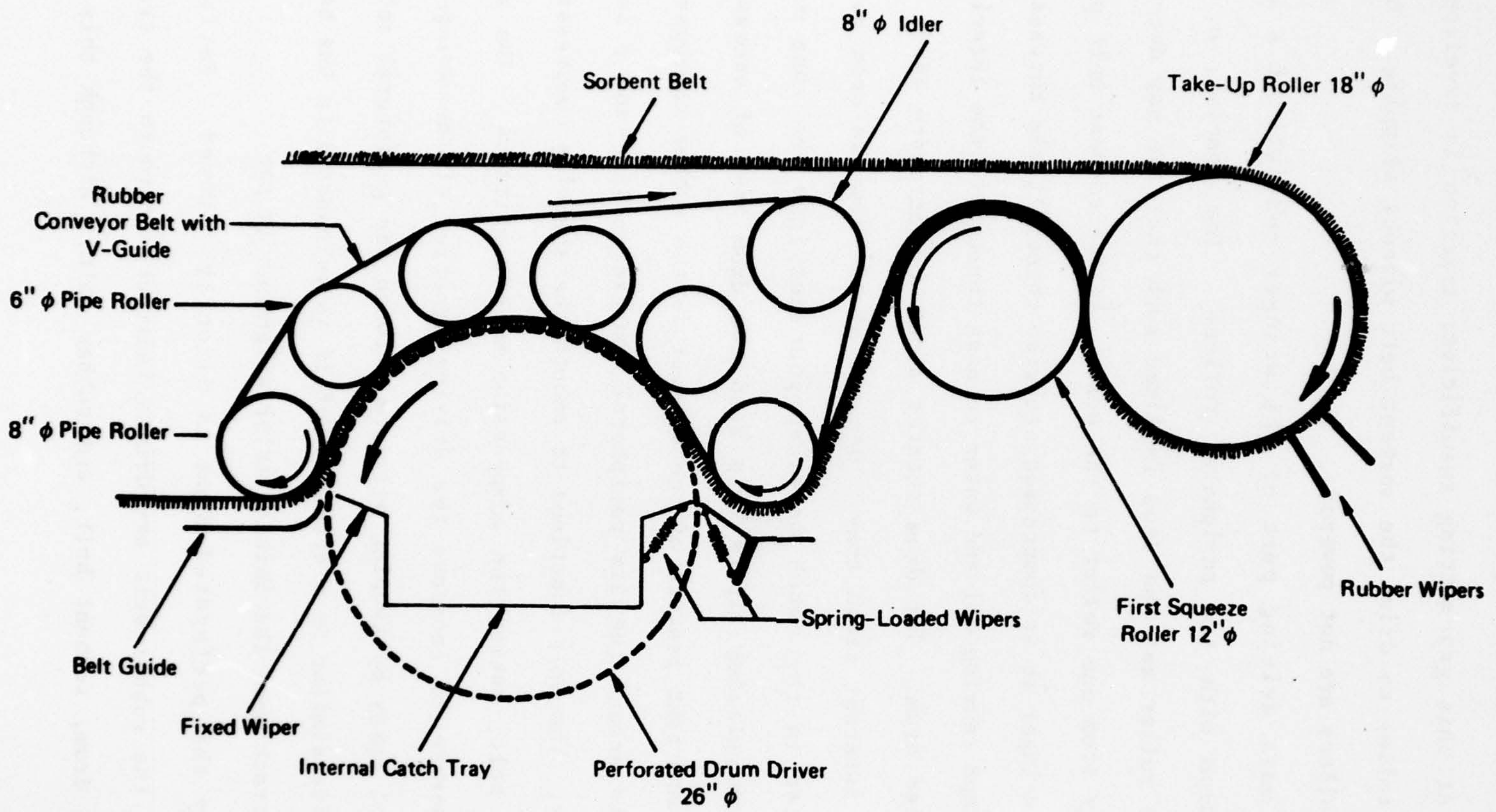


Figure 3. Prototype Wringer Arrangement

01470

large 0.50 inch to efficiently remove oil loosely held in the Astroturf cover of the belt without squeezing the felt core and causing high pore pressures. At this gap setting insufficient traction is developed at the squeeze roller to drive the sorbent belt without slipping. Therefore these rollers are not powered.

The main driving part of the wringer consists of a large perforated drum with six peripheral rollers. The spacing, or gap, between each roller and the drum is fixed such that the gap decreases exponentially from one roller to the next. As the sorbent belt passes through the wringer it is compressed stepwise through these successively decreasing gaps causing oil and water to pass through to the interior of the perforated drum. The drum rotates about a stationary shaft which supports an internal catch tray. One end of the drum is open so that oil and water in the catch tray can pour out into the sump of the skimmer. Springloaded wipers help keep the drum free of excess oil.

An important feature of the wringer is the rubber conveyor belt which travels around the six peripheral squeeze rollers and a seventh idler roller. The belt functions to smooth the stepwise compression of the sorbent belt, making the compression more continuous. The rubber belt also serves to increase the driving traction of the wringer and helps control spray by keeping oil from between the peripheral rollers. A rubber guide similar to a standard V-Belt is vulcanized to the belt to keep it on track once the initial idler alignment is set.

Only the perforated drum is directly powered. Peripheral rollers and the rubber belt are driven indirectly through the traction between the drum, sorbent belt, and rubber belt. Although this drive

arrangement does produce some shear load on the sorbent belt, that load is distributed over a large area (approximately 10 square feet) and probably does not affect belt life significantly. The simplicity gained by having only one wringer drive motor should outweigh any damaging effects of the shear load.

Design Comparison

A comparison of the new and original wringer designs shows many significant improvements in the mechanical aspects of the new design with some minor compromise in operating characteristics. Whereas the original design met all process goals to a high degree and fell short on mechanical goals, the new design falls slightly short on process goals to meet mechanical goals. For example, the additional squeeze roller behind the take-up roller is a simple mechanism for removing oil but increases belt tension and spray generation slightly. Using stepwise compression allows several large rollers to replace hundreds of small support bearings but increases the compression rates somewhat. The fact that some shear load is introduced by driving only the perforated drum has already been discussed. These changes mainly affect the operating life of the sorbent belt. In fact, test results presented in Chapter III show that wringing efficiency of the new design is better than the original under high speed conditions.

Overall, the compromises in operating characteristics are minor and relatively insignificant when compared to the mechanical improvements in the new wringer design. The comparison presented in Table 2 shows that the new wringer is a much simpler, lighter, and less expensive device.

TABLE 2

Mechanical Comparison of Wringers

Design Criteria	Original Wringer	New Wringer
Simple Design	Requires 200 roller bearings	Requires 18 ball bearings.
	Directly driven by hydraulic motor.	Chain and sprocket drive from hydraulic motor.
	Many moving parts in translation, oscillation, & rotation	Fewer moving parts which are only in rotation (except for rubber belt).
Low Power Requirement	High frictional losses due to large normal forces	Lower frictional losses since some components of normal load cancel. Coefficient of friction for ball bearings is only 40% of that for needle roller bearings used in original wringer.
Low Weight	Prototype estimated at 4,400 lbs	Prototype estimated at 3,000 lbs
Conventional Construction	Requires special castings and honeycomb sandwich construction technique.	Could be fabricated in any well-equipped machine shop. Requires no special construction techniques.
Size (main unit)	8 ft x 4 ft x 2-1/2 ft LWH Two wringers located side-by-side in center section. Access limited to top and one side of each unit.	4-1/4 ft x 4-1/4 ft x 3 ft LWH Two wringers staggered in center section for access to top and both sides of each unit.

III. WRINGER TESTING

Purpose

Having satisfied the mechanical design goals a test program was conducted to determine operating characteristics of the new wringer. The purpose of this program was to obtain quantitative and qualitative data on wringing efficiency, power requirements, and sorbent belt degradation and to find and correct any faults in the design.

Approach

The required information was obtained by running several series of tests comparing the performance of the original mock-up wringer to a similar mock-up of the new wringer. Tests were run using the skimmer mock-up built for the Houston and OHMSETT tests of 1976[2]. Since no facility was available for towing the mock-up over water, tests were conducted in a stationary mode with the mock-up mounted in a shallow catch tray. Oil was applied mechanically to the moving sorbent belt while the mock-up frame remained fixed. No water was used in any of the tests. This test method was more cost-effective than tow-testing since it required less equipment and fewer operators.

The drawback of stationary testing was that the resulting data could not be compared directly with the 1976 test data. However, since the original wringer worked satisfactorily in tow tests its performance in stationary tests could be used as a standard against which performance of the new wringer could be compared. It was reasoned that if the new wringer worked as well as the original in these comparative stationary tests, it would perform satisfactorily in tow tests and likewise in actual field conditions.

Apparatus

The test apparatus, shown in Figure 4, was designed to simulate actual oil skimming operations as closely as practicable. In this apparatus the mock-up was mounted in an outer tray located on a concrete slab which contained any excess test oil and prevented it from spreading across the slab. The section of sorbent belt which, in practice, would be floating on the water was supported and guided by an open-ended inner tray. Oil was applied to the belt through a manifold located beneath this inner tray. As the belt laid down on the tray, it contacted the oil much like it would contact a floating oil slick.

Wringing Efficiency Measurements

Wringing efficiency was determined by running a saturated belt through the wringer and measuring the volume of oil removed per unit time. A variable-speed positive-displacement gear pump metered oil to the application manifold at a sufficient rate to saturate the belt completely. Any excess oil drained from the belt as it left the inner tray and passed around the rear drum. The belt then entered the wringer carrying a fairly constant amount of oil. Wringing efficiency could be expressed in several ways such as gallons removed per foot of belt, or gallons removed per square foot, but gallons removed per minute was found to be the most convenient measure.

Another indicator of wringing efficiency was the volume rate of oil removed by the front rollers. If the wringer was efficient the sorbent belt was relatively dry as it passed through the front rollers and little oil was collected in the front catch pan. If, on the other hand, the wringer was inefficient a larger volume of oil was

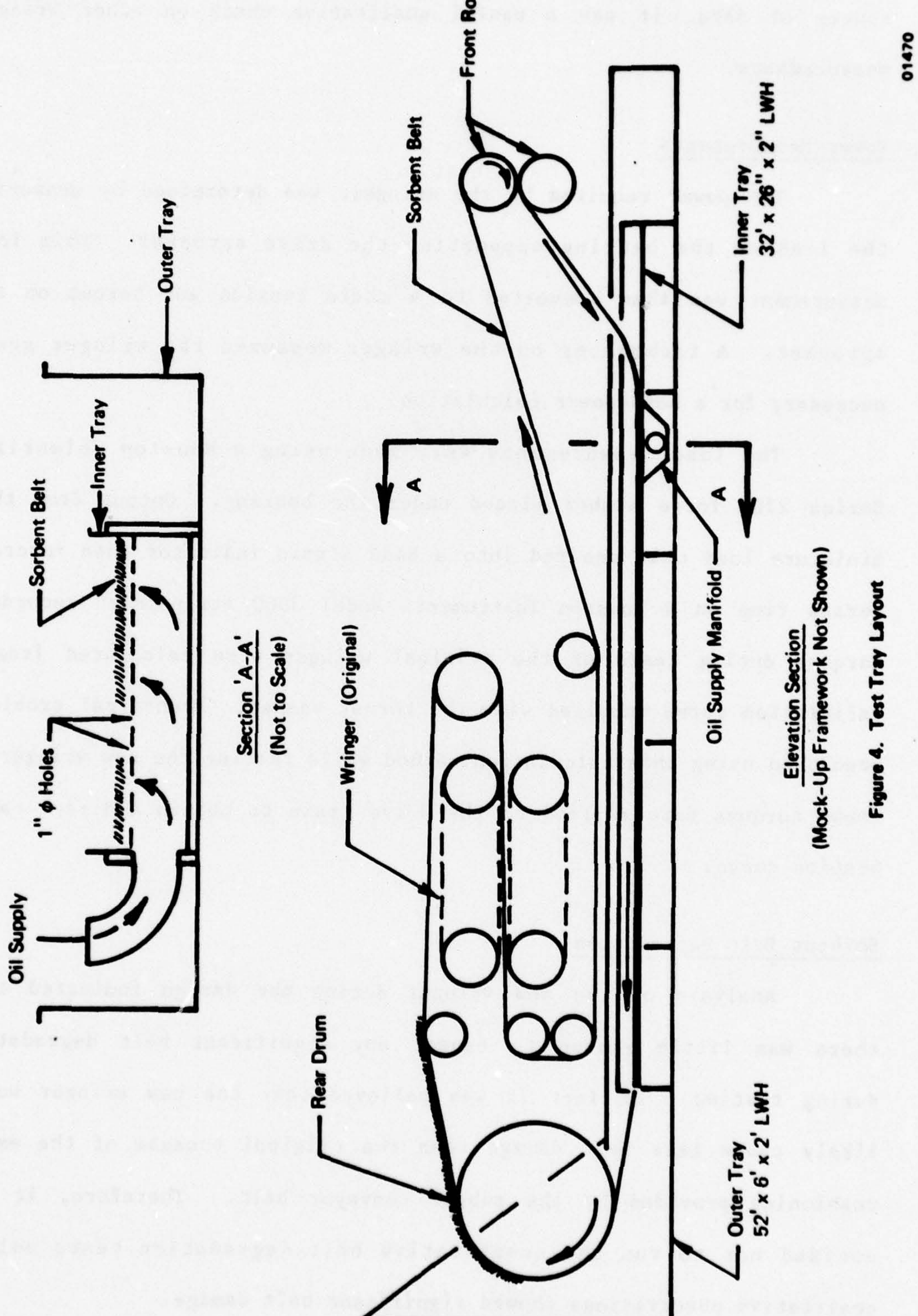


Figure 4. Test Tray Layout

removed by the front rollers. Although this indicator was not a primary source of data, it was a useful qualitative check on other wringer measurements.

Power Measurements

The power required by the wringers was determined by measuring the load on the bearing supporting the drive sprocket. This load measurement was then converted to a chain tension and torque on the sprocket. A tachometer on the wringer measured the wringer speed necessary for a horsepower calculation.

The load measurements were made using a Houston Scientific Series 2700 force washer placed under the bearing. Output from this miniature load cell was fed into a Budd strain indicator then recorded versus time on a Houston Instruments Model 3000 strip-chart recorder. Torques during tests of the original wringer were calculated from a calibration curve supplied with the thrust washer. Mechanical problems precluded using this calculation method while testing the new wringer so known torques were applied to the drive train to obtain a direct calibration curve.

Sorbent Belt Degradation

Analysis of the new wringer during the design indicated that there was little reason to expect any significant belt degradation during testing. In fact it was believed that the new wringer would likely cause less belt damage than the original because of the extra cushioning provided by the rubber conveyor belt. Therefore, it was decided not to run any quantitative belt degradation tests unless qualitative observations showed significant belt damage.

Test Oils

Two test oils were used in this program: a heavy viscous lubricant base stock and No. 2 diesel fuel. Properties of these oils are shown below.

Test Oil Properties

Oil Type	Viscosity	Specific Gravity
"Light" (No. 2 Diesel Fuel)	2.8 cSt @ 100F 4.8 cSt @ 60F	0.85 @ 60F
"Heavy" (LVI 750N Base Stock)	169 cSt @ 100F 899 cSt @ 60F	0.92 @ 60F

Viscosities (calculated from sample temperatures) during the tests ranged from 120 cSt to 310 cSt for heavy oil and 2.8 cSt to 3.5 cSt for light.

These two oils were used because the sorbent belt holds oil by two different mechanisms. Heavy, viscous oils are held by adhesion to the outer Astroturf cover while light, inviscid oils are held by capillary forces in the polypropylene felt core. Hence, wringer operating characteristics are affected significantly by oil type.

Wipers are very effective at removing viscous oil from the surface of the belt. Since both the original and new wringing systems employed wipers ahead of the main wringer, little difference was expected in their performance in heavy oil. After passing through the wipers there was not much heavy oil remaining in the belt for the main part of the wringer to remove. Tests using the light oil, however, were expected to show some difference in wringer performance. Wipers are not particularly effective in removing tightly held oil in the belt core.

Thus, the belt was still fairly saturated when it reached the main wringer. Since the light oil tests were more severe tests of the wringers and were expected to provide a better comparison, initial tests were run with heavy oil to check equipment adjustment and operating procedures. The more important light oil tests were run after all adjustments had been made and test procedures had been thoroughly practiced.

Test Procedures

Base data tests with the original wringer were run initially, first with heavy oil then light. The new wringer then was installed in the mock-up and the tests were repeated under identical conditions. In most cases only one test was run under each set of conditions. However, several test conditions were repeated to determine a level of accuracy and to validate any questionable data points.

Test procedures followed are outlined in Table 3. These are essentially the same as the procedures used in the 1976 OHMSETT tests.

Results

Tables 4 and 5 show the test data obtained using the original and new wringers, respectively. Series A tests were conducted with heavy oil to check out mechanical adjustments and test procedures. As discussed earlier, these tests were considered to be the less severe case since wipers removed most of the oil. Series B and C were conducted with light oil and were considered to be the more severe tests. In Series A and B oil was applied at a rate simulating the encounter of a

TABLE 3

Test Procedures

1. Fill oil supply tank and ready test equipment.

2. Start belt slowly and bring to desired speed.

3. Start oil pump and bring to desired speed.

4. Oil belt for pre-determined time to allow mock-up to come to a "steady-state" operating condition.

5. Begin sample collection.

6. Stop sampling after desired sample period by disengaging wringer and shutting off oil pump.

7. Pump out sample to calibrated tank.

8. Record:

   a. Sample volume
   b. Sample time
   c. Oil pump speed
   d. Wringer speed
   e. Sample temperature

TABLE 4

Test Results - Original Wringer

Test No.	Test Series	Oil Type*	Equivalent Slick Thickness Applied (mm)	Belt Speed (Knots)	Oil Recovery Rate (gal/min)	Wringer Power (HP)	Oil Removed By Front Rollers (gal/min)
0-1	A	H	10	2	70	-	-
0-2	A	H	10	4	122	-	-
0-3	A	H	10	6	104	-	-
0-4	A	H	10	6	120	-	14
0-5	A	H	10	3	88	-	-
0-6	A	H	10	5	125	-	12
0-7	A	H	10	4	116	-	13
0-8	B	L	10	2	60	2.3	3
0-9	B	L	10	3	93	3.0	15
0-10	B	L	10	4	110	5.0	15
0-11	B	L	10	5	126	6.3	20
0-12	B	L	10	6	118	9.7	30
0-13	C	L	6	3	74	2.8	17
0-14	C	L	6	4	98	4.2	20
0-15	C	L	6	5	91	5.6	25
0-16	C	L	6	6	89	7.2	35
0-17	C	L	6	7	89	8.7	-

*H - Heavy; LVI 750 N L - Light; No. 2. diesel

TABLE 5

Test Results - New Wringer

Test No.	Test Series	Oil Type*	Equivalent Slick Thickness Applied (mm)	Belt Speed (Knots)	Oil Recovery Rate (gal/min)	Wringer Power (HP)	Oil Removed By Front Rollers (gal/min)
N-1	A	H	10	2	50	-	17
N-2**	A	H	10	3	47	-	17
N-3	A	H	10	4	110	-	20
N-4	A	H	10	5	112	-	26
N-5	A	H	10	3	81	-	15
N-6	A	H	10	4	117	-	13
N-7	A	H	10	5	130	-	13
N-8	A	H	10	6	140	-	18
N-9	A	H	10	5	119	-	25
N-10	A	H	10	6	154	-	29
N-11	B	L	10	2	62	0.8	5
N-12	B	L	10	3	94	2.5	7
N-13	B	L	10	4	135	4.9	8
N-14	B	L	10	5	153	4.1	7
N-15	B	L	10	6	158	4.9	8
N-16	C	L	6	3	81	1.5	5
N-17	C	L	6	4	113	2.3	5
N-18	C	L	6	6	145	5.1	7
N-19	C	L	6	5	137	3.7	7

* H - Heavy; LVI 750 N L - Light; No. 2 diesel

**Invalid data - Oil supply cut off before end of run

slick 10mm thick. While the belt could handle 10 mm of heavy oil, this was far in excess of its sorption capacity in light oil. Therefore, Series C was run at a reduced oil application rate simulating a 6mm slick.

Figure 5 compares the performance of the two wringers in the Series A tests. As expected the two curves are quite similar. The new wringer removed slightly less oil at speeds up to 5 knots, then surpassed the original wringer at the 6-knot test limit. Although the 6-knot data point appears out of line, it is the average of two tests, both above the original wringer data point. The downward trend in the original wringer performance at speeds above 5 knots was also seen under similar conditions in the 1976 Houston tests.[2] At that time it was thought to be caused by large globules of oil breaking away from the belt at the rear drum. It now appears that this downward performance trend is a characteristic of the original wringer itself. The cause of this trend is unknown.

Figure 6 compares wringer performance in the Series B and C tests. In both cases performance of the two wringers was about the same at speeds below 3 knots while at 4 knots and above the new wringer performed significantly better. At the higher speeds 15 to 35 gal/min of oil was collected from the front rollers while testing the original wringer. Under identical conditions only 5 to 8 gal/min was collected testing the new wringer, indicating that the sorbent belt was leaving the wringer in a much drier condition. While the exact cause of the performance difference is not known, it was a dynamic effect since it occured only at speeds above 4 knots.

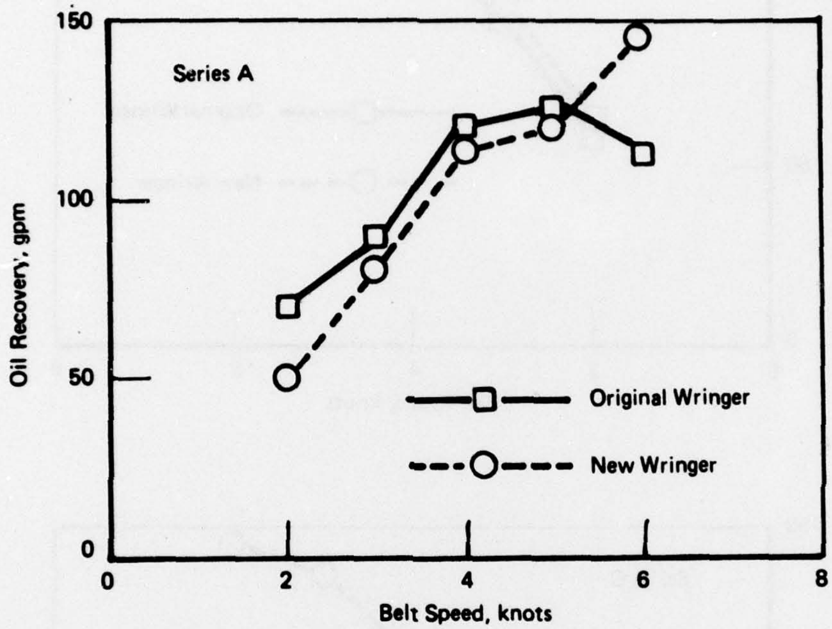


Figure 5. Wringer Performance - Heavy Oil

01470

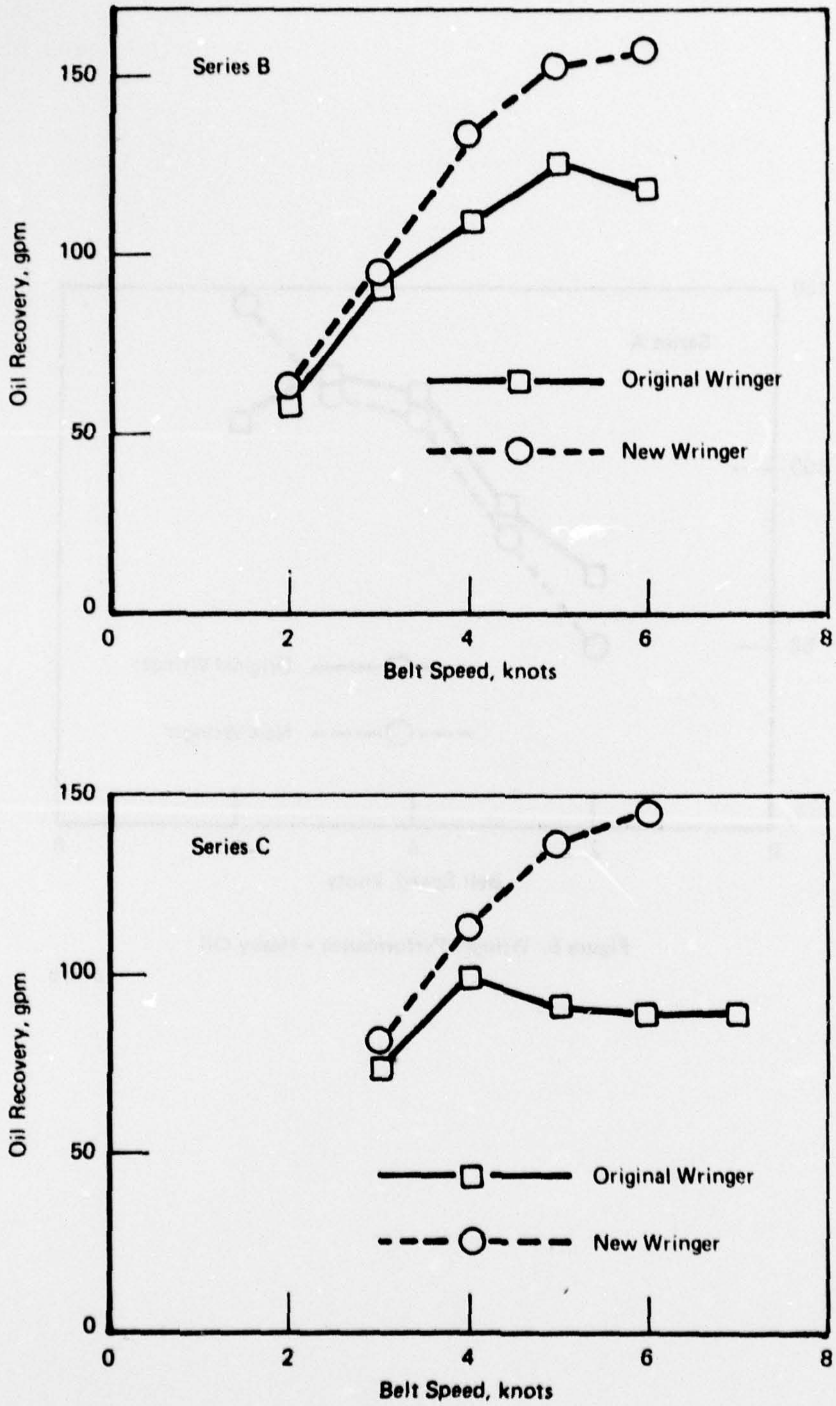


Figure 6. Wringer Performance – Light Oil

01470

Wringer power measurements, Figure 7, show that the new wringer required less power than the original. In Series C, where results were more uniform, there was a constant 2-1/2 horsepower difference at speeds from 4 to 6 knots. This difference was probably caused by lower mechanical friction losses in the new wringer. Irregularities in the Series B curve may have been caused by excess oil leaving the rear drum at speeds above 4 knots. No consistent quantitative power data were obtained in the Series A tests because of mechanical problems and improper operating procedures. However, it was observed that bearing loads were greater and the drive engine was more leavily loaded when using heavy oil.

Sorbent belt degradation was looked at only qualitatively for reasons previously discussed. The belt used in this program was the same one used in all the 1976 Houston and OHMSETT tests. No appreciable changes in the belt were observed. Several splices were torn during testing, but the belt was under abnormally high tension because of mechanical problems with the front rollers.

Observations

Throughout the testing program careful observations were made of the entire wringing system. Belt tracking problems, rewetting problems, and the operational characteristics of each component were looked for in particular. Significant observations of the new wringer are listed below.

1. The wiper removed about 50 percent of the light oil and about 70 percent of the heavy oil collected. Its effect on light oil probably would not be as predominant in actual operations since the Astroturf belt cover would not be as saturated.

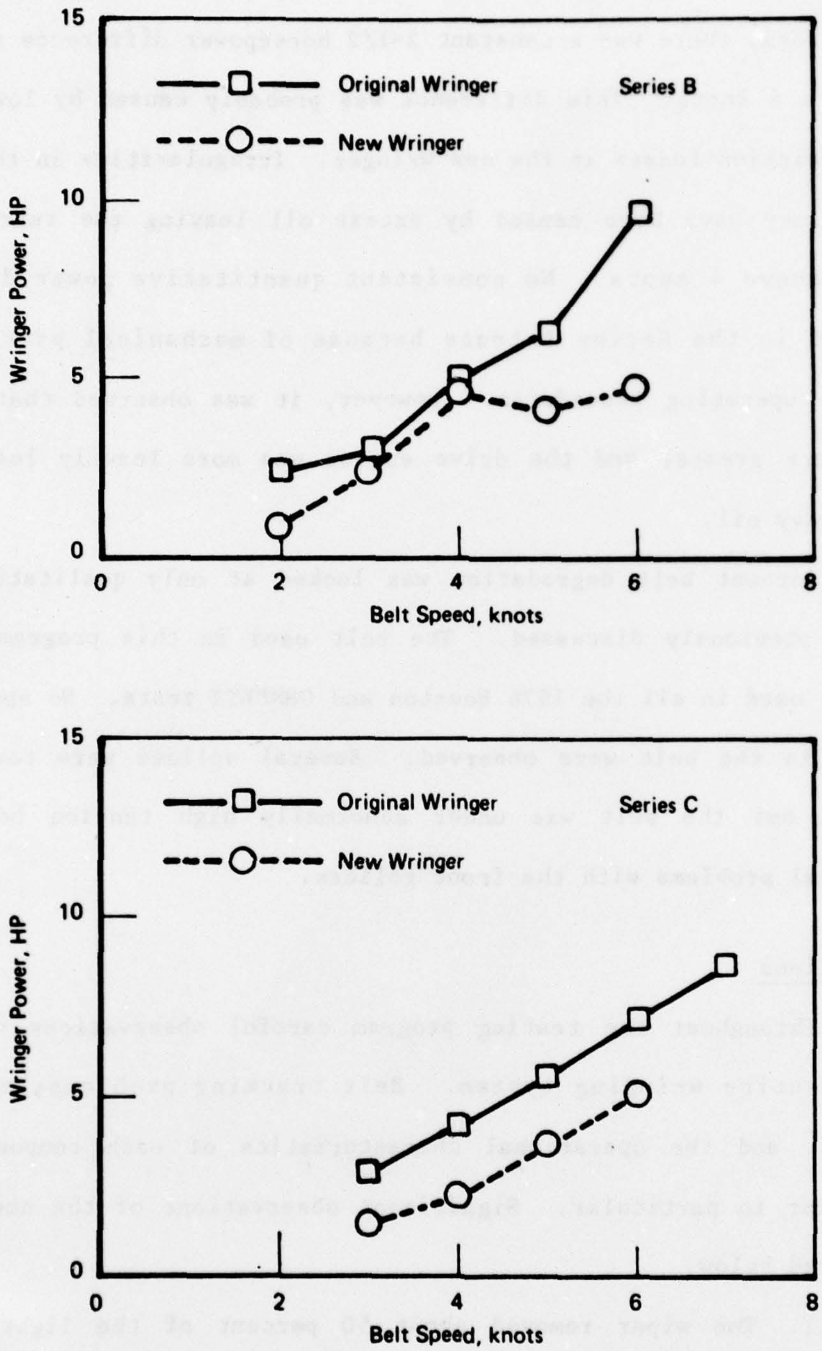


Figure 7. Wringer Power Curves

01470

2. The first squeeze roller removed about 25 percent of both the light and heavy oils. This component was quite efficient since it removed a large volume of oil but added very little mechanical complexity. However, it did generate a great amount of spray at high speeds which slightly rewetted the underside of the belt as it passed over the wringer. In actual operation, this spray would tend to create an oil/water emulsion.

3. The main wringer removed 25 percent of the light oil and only 5 percent of the heavy. (Of course these percentages varied somewhat with wringer speed.) Most of this oil was expelled as the belt passed under the first peripheral roller in the wringer. At speeds below 4 knots the oil dropped directly into the catch tray. At higher speeds it moved in a circular path within the perforated drum and was intercepted at the fixed wiper.

4. No problems were encountered tracking the sorbent belt or the rubber conveyor belt once the initial alignment had been set.

5. The rubber belt on the wringer cannot be directly powered. Attempts to drive it by powering the last peripheral roller failed because oil on the belt caused the roller to slip. Only driving the wringer by means of the perforated drum worked well.

6. The maximum test speed was limited to 6 knots because of the test apparatus, not the wringer mock-up. The wringer worked smoothly up to the test limit and probably could have operated at 8 knots with the proper drive train.

7. The new wringer ran much more quietly than the original.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The new wringer developed in this program is a simple device mechanically, yet works as well or better than the original wringer. It requires less power than the original and is light enough to meet the skimmer's air-transportability requirement. Its smaller size allows greater access for maintenance. The simplicity of its design provides a much higher level of confidence in its reliability. Overall, the new wringer design is a major improvement over the original.

Recommendations

It is recommended that the new wringer design be used in the prototype ZRV skimmer.

Detailed prototype plans and specifications should include the following changes from the mock-up design:

1. The wringer must be widened to accept 3-1/2-foot-wide belts used on the prototype skimmer.
2. Additional wipers should be placed inside the perforated drum to deflect oil downward into the catch tray at high speeds.
3. Since space is available, the end peripheral rollers and the idler should be increased in diameter to prolong the life of the rubber belt.
4. The prototype design should emphasize minimum weight construction and use materials compatible with the marine environment.

APPENDIX A

SKIMMER DESIGN CHANGES

Introduction

Concurrent with the wringer development program the preliminary skimmer design described in Reference 2 was revised to a detailed design. Most of the changes made were in the center section and involved the sorbent belt handling equipment, especially the wringers. Most changes did not affect the functioning of the skimmer, but were merely detailing additions such as defining locations of belt guide rollers and showing their construction details. Significant departures from the preliminary design, other than the wringers, are discussed below.

Significant Design Changes

1. Belt Tensioner - Port and starboard belt tensioning devices were added to the bow of the skimmer to hold the sorbent belts slightly above the water level after they leave the bow rollers. These are similar in function to the belt tension roller shown in Figure 9 of Reference 2 in that they increase the belt/oil contact time.

   In order to respond to wave motions each tensioner is constructed as a spring-loaded arm hinged at the forward end of the bow extension and again about 1/3 the distance from the free end. The lower section applies pressure to the belt through a torsional spring while the upper section is connected to an air cylinder which acts as an air spring. The cylinder also serves to fold up the tensioner for storage.

   Figure A-1 is a revision of Figure 4 in Reference 2 which shows the belt tensioners, new wringers, and rear belt guides.

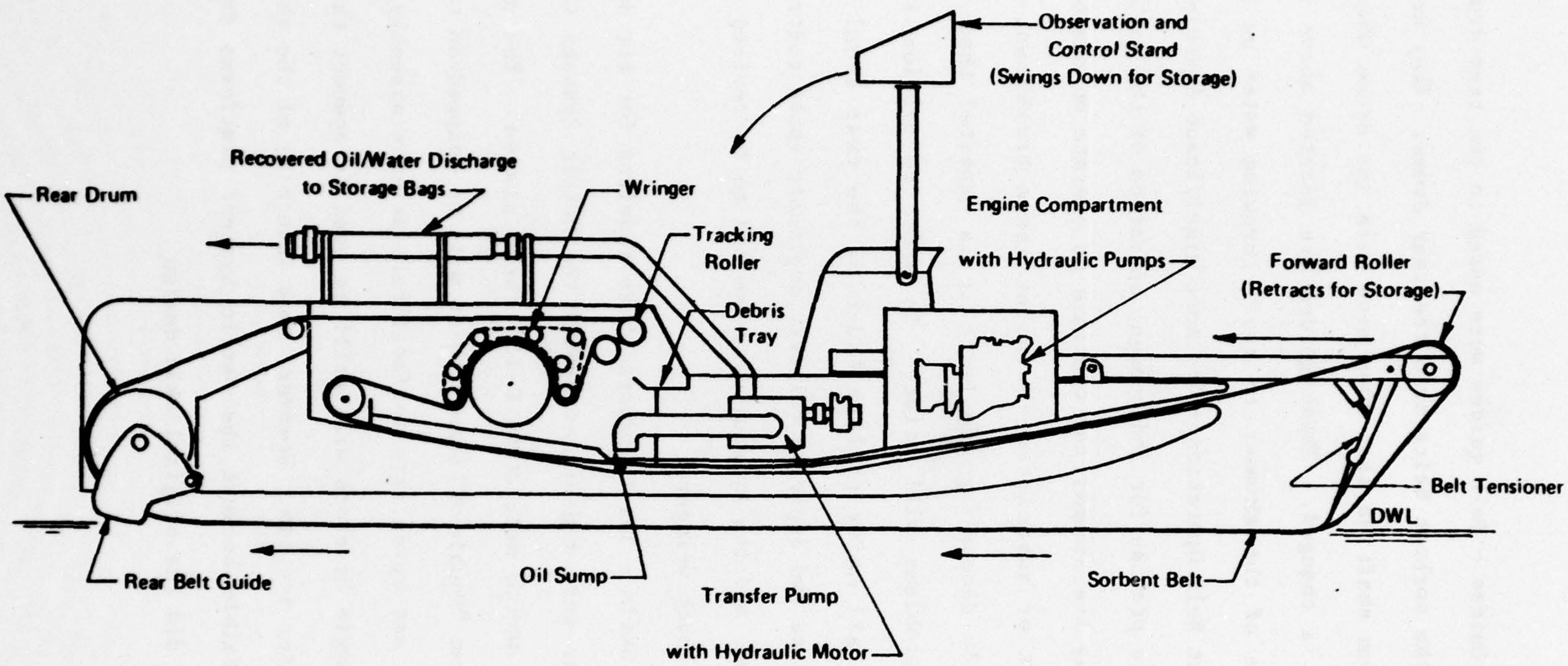


Figure A-1. Center Section Profile

01470

2. Rear Belt Guides - Belt guides were added to the rear drum assembly to guide the sorbent belts onto the rear drums. They are attached to the drum shaft so that they move with the drums when the drum elevation is changed. These guides are located above the design water line of the skimmer to avoid throwing water on the belts.

3. Independent Belt Operation - The most significant functional change made was to provide for independent operation of the sorbent belts. In this way the skimmer can continue to operate on one belt if the other belt or associated equipment has a breakdown. Also, by mechanically decoupling the belts it is expected that fewer belt tracking problems will arise. In order to provide independent operation all major rollers (such as the rear drum) had to be redesigned as two separate rollers, duplicate speed controls had to be provided, and the hydraulic system had to be revised to provide a pump for each wringer.

4. Transport Skids - The transport skids required for air delivery of the skimmer were redesigned around the Metric Systems Corporation platforms which mate with C-130 cargo planes. The new design includes two "Double-A" frames which will be shipped on the pontoon skids then set up on site to facilitate skimmer assembly. Tapered pins and angle brackets will still be used to connect the pontoons to the center section. However, ramp launching of the skimmer will not be possible because the Metric Systems platforms do not have rollers as did the original skid design.

REFERENCES

1. Ayers, R. R., et al, "A Zero-Relative-Velocity Belt Skimmer", prepared by Shell Development Company for the U.S. Coast Guard, Contract DOT-CG-42229-A. Final Report, April 1975.

2. Ayers, R. R., and J. M. Ward, "A Zero-Relative-Velocity Belt Skimmer, Stage II - Confirming Tests and Prototype Design", Prepared by Shell Development Company for the U.S. Coast Guard, Contract DOT-CG-42229-A. Final Report, May 1977.